

STUDIES ON BOREAL AGROMYZIDAE (DIPTERA). VI.
FURTHER *PHYTOMYZA* MINERS ON *SENECIONEAE* (COMPOSITAE)

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Seven species of *Phytomyza* mine the leaves of *Arnica* in northwestern North America, of which two holarctic species (*Phytomyza arnicae* Hering and *P. arnicicola* Lundqvist) are here recorded in North America for the first time. Three of these *Arnica*-miners are described as new, as follows: *Phytomyza saximontana* n. sp. (type-locality Jasper National Park, Alberta), *P. oreas* n. sp. (type-locality Jasper National Park, Alberta) and *P. campestris* n. sp. (type-locality Elk Island National Park, Alberta). Two new *Senecio*-miners are also described: *Phytomyza californica* n. sp. (type-locality Luther Pass, California) and *P. integerrimi* n. sp. (type-locality Ochoco National Forest, Oregon). New keys are given to the North American species of the *Phytomyza albiceps* and *P. robustella* groups.

Sept espèces de *Phytomyza* minent dans les feuilles de l'*Arnica* dans le Nord-ouest d'Amérique du nord, dont deux espèces holarctiques (*Phytomyza arnicae* Hering et *P. arnicicola* Lundqvist) sont signalées pour la première fois en l'Amérique du nord. Trois de ces *Arnica*-mineurs sont décrites comme nouvelles, tel que: *Phytomyza saximontana* n. sp. (localité-type Parc National Jasper, Alberta), *P. oreas* n. sp. (localité-type Parc National Jasper, Alberta) et *P. campestris* n. sp. (localité-type Parc National Elk Island, Alberta). Deux nouveaux mineurs du *Senecio* sont aussi décrites: *Phytomyza californica* n. sp. (localité-type Luther Pass, California) et *P. integerrimi* n. sp. (localité-type Forêt National Ochoco, Oregon). Des clefs nouvelles sont pourvues pour les espèces nord-américaines des groupes *Phytomyza albiceps* et *P. robustella*.

Sieben *Phytomyza*-Arten minieren in den Blättern von *Arnica* im nordwestlichen Nordamerika, von denen zwei holarctische Arten (*Phytomyza arnicae* Hering und *P. arnicicola* Lundqvist) hier erstmals für Nordamerika nachgewiesen werden. Folgende drei dieser *Arnica*-Minierer werden neu beschrieben: *Phytomyza saximontana* n. sp. (Fundort vom Typus Jasper Nationalpark, Alberta), *P. oreas* n. sp. (Fundort vom Typus Jasper Nationalpark, Alberta) und *P. campestris* n. sp. (Fundort vom Typus Elk Island Nationalpark, Alberta). Auch zwei neue *Senecio*-Minierer werden neu beschrieben: *Phytomyza californica* n. sp. (Fundort vom Typus Luther Pass, California) und *P. integerrimi* n. sp. (Fundort vom Typus Ochoco Nationalforst, Oregon). Neue Bestimmungstabellen für die nordamerikanischen Arten der *Phytomyza albiceps*- und *P. robustella*-Gruppe werden aufgestellt.

This paper continues my treatment of the *Phytomyza* miners of *Senecioneae*, commenced in Part II of this series (Griffiths, 1972). I am now able to present a revision of the miners of *Arnica*, including description of three new species, as a result of my extensive breeding of flies from this host genus in North America. At the same time it seems useful to describe two new *Senecio*-feeders which have come to light in the Frick collection and to summarize the information available on the *Phytomyza* miners of other genera of *Senecioneae* not treated in Part II. The holotypes of the new *Arnica*-feeders will be deposited in the Canadian National Collection (Ottawa). Both holotypes from the Frick collection belong to the California Academy of Sciences (San Francisco).

The greatest diversity of *Arnica* species is found in mountainous and subarctic areas of northwestern North America, where it is believed that the group originated. Here several species can often be found growing together, especially in alpine meadows where they are generally abundant. Their identification requires much care. In this paper I have followed the species concepts and nomenclature of Maguire's (1943) authoritative monograph, which has been substantially followed by all subsequent authors. Not surprisingly more species of agromyzid leaf-miners can be found on *Arnica* here than in Europe, where the group is represented by only two monophagous species (both of which also occur in North America). With one exception (*conyzae*), all the *Phytomyza* miners of *Arnica* are confined to this host genus. I have found no evidence that any of the miners are vicariants on different species of *Arnica*; for instance, all the five species of miners known from Jasper National Park have been bred from *Arnica cordifolia* Hook., and in mid-August 1971 on Mount Cavell larvae of four of them were found feeding on this plant at the same time.

In Part II I briefly discussed records of the *Phytomyza syngenesiae* group, which I have subsequently (Griffiths, 1974) separated from *Phytomyza* as part of *Chromatomyia*. There is little information to be added. There are records of "*Phytomyza atricornis* Meigen" on *Adenostyles*, *Arnica* and *Doronicum* in Europe (Hering, 1957). These presumably refer either to *Chromatomyia syngenesiae* Hardy or to *C. horticola* (Goureau). One male bred from *Doronicum austriacum* Jacq. in Berlin Botanical Gardens has been definitely identified as *horticola* (Griffiths, 1967).

DIAGNOSIS

In Part II (Griffiths, 1972), I alluded to certain difficulties with Spencer's (1969) key to the *Phytomyza* (*sensu lato*) species of Canada and Alaska. Subsequently (Griffiths, 1974), I have prepared an entirely new key to the *Chromatomyia* species of North America, no longer attempting to key these by amending Spencer's *Phytomyza* key. Further new keys are now offered for North American species of the *Phytomyza albiceps* group and the *P. robustella* group. Eventually I hope to be able to include all these keys in a revised general key to *Phytomyza s.l.* But it seems premature to attempt this until I have been able to review additional groups.

The new keys rely heavily on characters of the male aedeagus, and it will not be possible to identify with them most females unassociated with males. This defect is unavoidable, since no reliable criteria have been found for identifying females of many groups of Agromyzidae. The delimitation of the *albiceps* and *robustella* groups adopted for the purpose of these keys may be explained as follows.

(1) *Phytomyza albiceps* group. — This group seems characterized in its groundplan by certain apomorphic characters of the aedeagus, namely (i) reduction of the mesophallus, and (ii) the presence of spinules. While the former character is found also in certain other groups of *Phytomyza*, the latter is unique (autapomorphic) to the *albiceps* group. I use the term mesophallus to mean a cylindrical pigmented sclerite enclosing the expanded part of the ejaculatory duct at the base of the distal section (posterior to the bifid distiphallus). A small mesophallus is retained in *californica* (Fig. 8-9), but in most species of this group this is represented by no more than a slender strip or spot of pigmentation. In some species the pigmentation of the distiphallus has also been lost, resulting in an entirely transparent distal section. The position and number of spinules varies considerably between species and is often of diagnostic importance. They are entirely absent in five species (*agromyzina*, *osmorhizae*, *solidaginivora*, *lanati* and *tingitica*), in my opinion secondarily since other characters indicate that these species belong to the *albiceps* group. I include in the *albiceps* group various leaf-miners of Compositae, Umbelliferae and Cornaceae (in Europe also of Campanulaceae), including those with dark frons usually called

the *obscurella* group. In addition it appears from the structure of the aedeagus that the recently described *Phytomyza oxytropidis* Sehgal (on *Oxytropis*, Leguminosae) is a rather modified species of the *albiceps* group. However, I now exclude from this group *Phytomyza conioselini* Griffiths (contrary to my remarks in Part III), since I doubt that the highly modified aedeagus of this species can have been derived from the type characteristic of the *albiceps* group. *Phytomyza ciliolati* Spencer doubtless belongs to the *albiceps* group, but I must omit it from the key for the present as the male is undescribed.

(2) *Phytomyza robustella* group. — The species of this group are all, as far as known, feeders on Compositae (producing leaf-mines, stem-mines or gall-like swellings). The characterization of the group remains unsatisfactory, as explained in Part II (Griffiths, 1972), because no autapomorphic characters have been demonstrated. Rather the group may be recognized by a combination of apomorphic characters which are not confined to it, as follows: (i) puparia remaining in plant tissue, with anterior spiracles turned downwards so that they project ventrally through the epidermis, and (ii) mesonotal setulae reduced in number (acr at most in three rows; 0-6 postsutural ia). The appearance of the aedeagus is also characteristic, but I have not been able to identify any autapomorphic characters.

A key with worldwide coverage to the *Phytomyza* and *Chromatomyia* miners of *Arnica* is also presented below. These are the only known leaf-miners of *Arnica*, but stem-feeding *Ophiomyia* and *Melanagromyza* species are also known from *Arnica* in Europe.

Key to North American species of *Phytomyza albiceps* group

1. Centre of frons largely brown or black (or at least ochreous in *demissa* and *agromyzina*) 2
- Centre of frons largely yellow or orange-yellow 8
2. (1) Costal section mg_2 only slightly longer than mg_4 ; acr very few (3-6). Aedeagus as figured by Sehgal (1971, Fig. 119) *P. oxytropidis* Sehgal
- Costal section mg_2 at least 1.8 times as long as mg_4 ; acr more numerous 3
3. (2) Tibiae and tarsi yellow. Aedeagus with unpigmented distal section (Spencer, 1969, Fig. 395) *P. agromyzina* Meigen
- Tibiae and tarsi brown or black 4
4. (3) Sclerites of medial lobe of aedeagus reduced; distal section short, without pigmented distiphallus (Griffiths, 1973b, Fig. 17-18) *P. archangelicae* Hering
- Aedeagus not as above, with sclerites of medial lobe well developed 5
5. (4) Basal section of aedeagus with one or two rows of conspicuous spinules 6
- Basal section of aedeagus without or with only very small spinules 7
6. (5) Aedeagus as figured by Spencer (1969, Fig. 425-426), with pigmented distiphallus well developed. Costal section mg_2 less than three times as long as mg_4 *P. demissa* Spencer
- Aedeagus as figured by Griffiths (1973a, Fig. 7); distal section with only weak traces of terminal pigmentation (distiphallus). Costal ratio mg_2/mg_4 3.4-3.5 *P. sitchensis* Griffiths
7. (5) Aedeagus as figured by Spencer (1969, Fig. 473). Costal ratio mg_2/mg_4 3.5-4.5 ... *P. osmorhizae* Spencer
- Aedeagus as figured by Griffiths (1973a, Fig. 1-2). Costal ratio mg_2/mg_4 2.2-2.4 ... *P. cnidii* Griffiths
8. (1) Scutellum whitish yellow. Aedeagus as Fig. 8-9 *P. californica* n. sp.
- Scutellum dark 9
9. (8) First and second antennal articles yellow. Aedeagus as figured by Spencer (1969, Fig. 457) *P. matricariae* Hendel

- Second antennal article dark (at most first article yellowish) 10
10. (9) Distal section of aedeagus without terminal pigmentation (distiphallus) 11
- Distal section of aedeagus with terminal bifid area (distiphallus) pigmented . . 16
- 11.(10) Distal section slender, downcurved apically; sclerotization of medial lobe V-shaped; dense band of large spinules near dorsal margin of left basal sclerite (Fig. 1, 4, 5). Mesonotum almost entirely dark, with traces of pale coloration only at corners of humeral calli 12
- Distal section relatively large; sclerites of medial lobe discrete or fused to form loop (Griffiths, 1973b, Fig. 1, 2, 5, 6, 8, 9). Mesonotum with patches of brown or whitish yellow on sides (at least on humeral callus and upper part of sutural triangle) . . 14
- 12.(11) No spinules on right side of aedeagus; V-shaped sclerotization of medial lobe short and somewhat asymmetrical (Fig. 4) *P. tundrensis* Spencer
- Small patch of spinules on right side of aedeagus near apex of right basal sclerite; sclerotization of medial lobe forming slender symmetrical V (Fig. 1, 2, 5) 13
- 13.(12) Spinule band on left side of aedeagus extending about to apex of left basal sclerite (Fig. 1). Wing length over 3 mm *P. arnicae* Hering
- Spinule band on left side of aedeagus shorter, ending well posterior to apex of left basal sclerite (Fig. 5). Wing length up to 2.35 mm (♂) and 2.6 mm (♀) *P. arnicicola* Lundqvist
- 14.(11) Conspicuous patch of 6-11 spinules on left side near apex of basal section of aedeagus (Griffiths, 1973b, Fig. 2-3) *P. pastinacae* Hendel
- 0-3 dorsal spinules in above position 15
- 15.(14) Aedeagus as figured by Griffiths (1973b, Fig. 8-9), entirely without spinules *P. tlingitica* Griffiths
- Aedeagus as figured by Griffiths (1973b, Fig. 5-6), with 2-6 spinules on right side near apex of right basal sclerite *P. spondylii* Robineau-Desvoidy subsp. *heracleiphaga* Spencer
- 16.(10) Aedeagus without spinules on basal section 17
- Aedeagus with spinules on some part of basal section 18
- 17.(16) Aedeagus as figured by Spencer (1969, Fig. 452), with strips of sclerotization below main sclerites of medial lobe; distiphallus short. Sides of mesonotum dark *P. lanati* Spencer
- Aedeagus as figured by Spencer (1969, Fig. 506-507), without such strips of sclerotization; distiphallus long. Sides of mesonotum partly yellow *P. solidaginivora* Spencer
- 18.(16) Aedeagus as Fig. 6-7, with spinules arranged in more or less semicircular band at apex of basal section. Head as Fig. 26, with small eyes (orbits broadly projecting above eye in lateral view; genae in middle about half eye height) *P. saximontana* n. sp.
- Aedeagus not as above. Head with larger eyes (orbits at most narrowly projecting above eye in lateral view; genae in middle at most about 2/5 eye height) 19
- 19.(18) Aedeagus as figured by Griffiths (1972, Fig. 6-7), with small distiphallus remote from basal section; spinules few, situated distally in rows along dorsal margins of basal sclerites (equally developed on both sides) 20
- Aedeagus not as above 21
- 20.(19) Thorax almost entirely black *P. tussilaginis* Hendel subsp. *kevani* Griffiths
- Sides of thorax extensively whitish. . *P. tussilaginis* Hendel subsp. *petasiti* Spencer
- 21.(19) Aedeagus as figured by Griffiths (1972, Fig. 1-2), with spinules in dense lateral patches on distal half of basal section *P. alpina* Groschke

- Aedeagus with single row of large spinules extending from base of basal section 22
- 22.(21) Aedeagus as figured by Spencer (1969, Fig. 404-405), with only short row of spinules *P. asterophaga* Spencer
- Aedeagus as figured by Sehgal (1971, Fig. 126), with long row of spinules *P. solidaginophaga* Sehgal

Key to North American species of *Phytomyza robustella* group

1. Colour almost entirely yellow, including all antennal articles, legs and scutellum. Aedeagus as figured by Spencer (1969, Fig. 455-456) *P. major* Malloch
 - Thorax, antennae and legs largely dark 2
2. (1) Costal ratio mg_2/mg_4 2.6. Third antennal article with long pubescence (Griffiths, 1972, Fig. 31); frons deep yellow. *P. hyperborea* Griffiths
 - Costal ratio lower (at most 2.3 in *nagvakensis*). 3
3. (2) Distal section of aedeagus scarcely pigmented (Spencer, 1969, Fig. 437-438). Frons brownish yellow *P. hebronensis* Spencer
 - Distal section of aedeagus with pigmented distiphallus well developed 4
4. (3) Aedeagus as figured by Spencer (1969, Fig. 392-393), with distiphallus remote from basal section. Frons yellow; eyes small (orbits projecting above eye in lateral view; genae almost half eye height) *P. affinalis* Frost
 - Distiphallus not so remote from basal section of aedeagus 5
5. (4) Medial lobe of aedeagus with pigmented central spur (Fig. 15-16). Frons brown or red-brown *P. oreas* n. sp.
 - Medial lobe of aedeagus without or with membranous central spur 6
6. (5) Aedeagus as figured by Spencer (1969, Fig. 466-467), with pigmented sclerotization of medial lobe. Wing length 3.2 mm (δ). Frons orange-yellow *P. nagvakensis* Spencer
 - Medial lobe of aedeagus with little or no pigmentation. Wing length shorter (at most 2.8 mm in *lugentis* and *integerrimi*). 7
7. (6) Orbits distinctly projecting above eye in lateral view; genae in middle 1/2 to 2/5 of eye height. Frons brown to reddish black. Aedeagus as figured by Griffiths (1972, Fig. 23-24) *P. hypophylla* Griffiths
 - Orbits not or only very narrowly projecting above eye in lateral view; genae in middle 1/3 to 1/4 of eye height 8
8. (7) Aedeagus as Fig. 22-23, with relatively long distiphallus flanked basally by large unpigmented lateral lobes. Frons brown *P. integerrimi* n. sp.
 - Distiphallus not so long 9
9. (8) Centre of frons brown or ochreous. Aedeagus as figured by Griffiths (1972, Fig. 17-18) *P. lugentis* Griffiths
 - Centre of frons whitish yellow to yellow-brown 10
10. (9) Aedeagus as Fig. 21, with anterior margin of distiphallus bent downwards *P. arnicivora* Sehgal
 - Aedeagus as Fig. 18, with anterior margin of distiphallus almost straight *P. campestris* n. sp.

Key to *Phytomyza* and *Chromatomyia* mines on *Arnica*

1. Puparia formed inside leaf, with anterior spiracles turned downwards, projecting through epidermis (see Griffiths, 1972, Fig. 27). Mines linear throughout 2
 - Puparia formed outside leaf, or, if inside (in *conyzae*), anterior spiracles not projecting

- and semicircular exit slit cut by larva before puparium formation
 (*Phytomyza albiceps* group) 4
2. (1) Mines normally less than 10 cm long, mostly over 1 mm wide terminally
 *Chromatomyia syngenesiae* group
 Mines of a species of this group, either *C. syngenesiae* Hardy or *C. horticola* (Goureau), have been reported on
Arnica in Europe (Hering, 1957).
- Mines longer, about 1 mm wide terminally. North America
 (*Phytomyza robustella* group) 3
3. (2) Faeces deposited as narrowly separated particles or beaded strips (Fig. 30)
 *Phytomyza oreas* n. sp.
 or *Phytomyza arnicivora* Sehgal
- Faeces deposited as well separated particles (mostly by over 1 mm) (Fig. 31)
 *Phytomyza campestris* n. sp.
4. (1) Mines basically linear (about 2 mm wide terminally), at most with secondarily blotchy
 areas formed by convoluted linear channels (Fig. 29) 5
- Mines linear at origin but soon broadened into blotch (Fig. 27-28) 6
 Mines of *Phytomyza arnicicola* Lundqvist will be taken to this couplet, but I cannot include them in this key
 until good specimens are available.
5. (4) Puparia formed outside or inside leaf; anal lobes scarcely prominent. Europe
 *Phytomyza conyzae* Hendel
- Puparia normally formed outside leaf, with prominent anal lobes. North America.
 *Phytomyza saximontana* n. sp.
6. (4) Mines (Fig. 27) white or greenish white when fresh, with little feeding debris. Hol-
 arctic *Phytomyza arnicae* Hering
- Mines (Fig. 28) brown or blackish due to presence of much feeding debris. North
 America *Phytomyza tundrensis* Spencer

TREATMENT OF SPECIES

(a) the *Phytomyza albiceps* group

In addition to the species of this group reported from Senecioneae in Part II, I have material of four further species from *Arnica* and one from *Senecio* in North America. I describe these below, and complete my treatment of species mining Senecioneae by reviewing the available information on miners of *Homogyne*, *Doronicum* and *Adenostyles*. Contrary to my previous remark (Griffiths, 1972: 382), I am now satisfied from the discussion of Cronquist (1955) that *Adenostyles* is properly included in the Senecioneae.

The four *Arnica*-feeding species are probably monophyletic, as evidenced by the fusion of the right and left basal sclerites near the base of the aedeagus on its left side; this is an apomorphic character not reported for any other species. Further information on the distribution of these species will be of biogeographical interest. I can now state that both the species described from *Arnica* in Europe are holarctic, so there seems to be no purely palaeartic element in the *Phytomyza* fauna of these plants.

In addition to the species discussed below, Sasakawa (1954, 1961) has reported "*Phytomyza lappae* Robineau-Desvoidy" as mining two genera of Senecioneae, *Adenocaulon* and *Ligularia*. Unfortunately the source of the male whose genitalia were figured was not stated. It certainly does not belong to the true *lappae*. Further information is needed before these records can be assessed (see also my remarks in Part II, page 388).

Additional notes on *Phytomyza tussilaginis* Hendel, *P. alpina* Groschke and *P. senecionis*

Kaltenbach (all described in Part II) are also appended below.

Phytomyza arnicae Hering 1925

Phytomyza arnicae Hering. Hering, 1925: 511. —1927: 114. De Meijere, 1928: 166. —1937: 213. Hendel, 1934: 351. Syntypes ♂♀, Bavaria (Germany), in Zoologisches Museum, Humboldt Universität, Berlin.

Adult. — Head (Fig. 25) with orbits only narrowly projecting above eye in lateral view; genae in middle 1/3 to 2/5 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus about twice width of eye. At least four well-developed pairs of orbital setae (two posteriorly directed ors and two inwardly directed ori) present; posterior ors half to almost as long as anterior ors; two pairs of long ori and in most specimens also shorter third pair; orbital setulae irregularly distributed, more or less two-rowed posteriorly in most specimens. Peristomal margin with vibrissa and 3-9 upcurved peristomal setulae. Third antennal article rounded distally, with rather short fine pubescence.

3 + 1 dc; acr numerous, in 4-5 rows anteriorly in European specimens, in 6-7 rows anteriorly in North American specimens; presutural and postsutural ia numerous; inner pa 1/2 to 2/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.5-2.75 in material examined (up to 3.25 according to Spencer, in press). Wing length in European specimens 2.5-2.8 mm (♂) and 3.0 mm (♀); in North American specimens 3.2 mm (♂) and 3.6-3.65 mm (♀).

Frons yellow or orange-yellow centrally, with ocellar plate and vertex contrastingly black (vte on dark ground; vti on boundary between dark and pale ground); orbits yellow or ochreous yellow, in most specimens somewhat grey-dusted and with spots of infuscation around bases of orbital setae. Face yellow at sides, with variable degree of infuscation in antennal pits (strongly infuscated in North American specimens, weakly so in those from Europe). Genae yellow. Occiput black. Antennae with first article yellow-brown, second and third articles black. Palpi black; labella yellow. Thorax strongly grey-dusted, scarcely shining, largely dark with pale coloration only at corners of humeral calli (especially around anterior spiracles) and along seams of sutures (especially notopleural and mesopleural sutures); wing base and squamae whitish, latter with dark margin and fringe. Legs largely dark, with tips of femora contrastingly yellow. Abdomen largely dark brown or black. Basal cone of ovipositor (♀) grey-dusted on about basal half.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres partly delimited from perianthrium by suture on outer side, bearing numerous fine setulae. Pregonites extending ventrally, shielding base of aedeagus at rest. Aedeagus as Fig. 1-2; basal sclerites narrow, joined on left side at base; dense band of large spinules on left side near dorsal margin of left basal sclerite, extending about to apex of that sclerite; on right side small patch of spinules near apex of right basal sclerite; sclerites of medial lobe fused distally, forming slender symmetrical V; distal section appearing as slender, largely transparent tubule in lateral view, with one or two spots of pigmentation at base but bifid distal area (distiphallus) entirely unpigmented (contrast *saximontana*). Ejaculatory apodeme rather large (Fig. 3), strongly pigmented in North American specimens, weakly so in those from Europe.

Puparium and third instar larva. — Described by de Meijere (1928, 1937). Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles knob-shaped, with 15-17 irregularly distributed bulbs in North American specimens, with 10-13 bulbs in those from Europe (de Meijere); posterior spiracles on short conical processes, with bulbs in broad (nearly circular) ellipse (20-24 bulbs in North American specimens, 15-20 in those from Europe according to de Meijere). Puparia dark red-brown, 2.7-3.0 mm long in North American specimens,

with prominent anal lobes.

Mine. — Larvae leaf-miners on *Arnica*. Mine (Fig. 27) at origin with short linear channel but soon broadened into large blotch, appearing white or greenish white in reflected light when fresh (contrast *tundrensis*); faeces deposited as fine particles irregularly throughout mine, in some cases partly forming short beaded strips; mines mostly on upper surface of leaf (rarely on lower surface according to Hering, 1925), deep, in some cases with full-depth patches (Hering, 1925); vicinity of mines on *Arnica montana* L. often discoloured violet-red (Hering, 1925); larvae leaving leaf through semicircular slit (on upper or lower surface) before puparium formation.

Figures of the leaf mines have previously been published by Hering (1927, 1957) and Rydén (1934).

Material examined. — Syntype ♂, 1 ♂ paratype from larvae 30.vi.24 on *Arnica montana* L., Ludwigsthal, Bayrische Wald, Germany, emerged 31.i-1.ii.25 (forced), leg. O. & M. Hering (no. 2519).

2 ♂♂ from larvae 23.viii.71 on *Arnica alpina* (L.) subsp. *tomentosa* (Macoun), near Mount Cavell Chalet (7600 feet elevation), Jasper National Park, Alberta, emerged 6.v.72, leg. G. C. D. Griffiths; 2 ♀♀ from larvae 15-23.viii.71 on *Arnica cordifolia* Hook., same locality (5800-6700 feet elevation), emerged 8.v.72, leg. G. C. D. Griffiths.

Other records. — Additional European records, all based on mines on *Arnica montana* L., are as follows.

Germany — Erzgebirge and Riesengebirge (Hering, 1925; Buhr, 1964).

Austria — Lofer district and Zillertaler (Hendel, 1934); Schöneben, Böhmerwald (sheet in Hering's mine herbarium).

Sweden — Mines reported by Rydén (1934, 1947) in Skåne and Småland. His records of caught flies (Rydén, 1947 & 1951) require checking.

Remarks. — My specimens of *arnicae* from Alberta are remarkable for their very large size (wing length 3.2-3.65 mm). They stand out in this respect from all other *Phytomyza* miners of *Arnica*. Probably they represent a distinct subspecies. But I make no formal proposal at this time, since so little material is available.

As far as known this species is univoltine throughout its range.

Phytomyza tundrensis Spencer 1969

Phytomyza tundrensis Spencer. Spencer, 1969: 281. Holotype ♂, Cold Bay (Alaska), in Canadian National Collection, Ottawa.

Adult. — As described for *arnicae*, except as follows.

3 ori in all specimens. 2-4 upcurved peristomal setulae. Acr in 3-5 rows anteriorly. Costal ratio mg_2/mg_4 2.5-3.0. Wing length: ♂, 2.5-2.85 mm; ♀, 2.85-2.9 mm.

Colour of head as in North American specimens of *arnicae*, with face extensively infuscated in antennal pits.

Aedeagus (Fig. 4) with band of large spinules on left side shorter, ending well before apex of left basal sclerite; patch of spinules on right side absent; V-shaped sclerotization of medial lobe shorter and somewhat asymmetrical (left arm of V slightly shorter than right). Ejaculatory apodeme moderately pigmented, shaped as in *arnicae*.

The aedeagus was previously figured by Spencer (1969).

Puparium and third instar larva. — Similar to those of *arnicae*. Anterior spiracles with 12-16 bulbs; posterior spiracles with 15-23 bulbs. Puparia yellow-brown to dark red-brown, 2.1-2.5 mm long, with more or less prominent anal lobes.

Mine. — Larvae leaf-miners on *Arnica*. Mine (Fig. 28) confined to upper surface of leaf,

linear at origin but soon broadened into large blotch, appearing brown or blackish in reflected light due to presence of much feeding debris (forming fine herring-bone pattern); faeces mostly deposited in beaded strips; larvae leaving leaf through semicircular slit on upper surface before puparium formation.

Material examined. — 1 ♂ from larva 17.vii.68 on *Arnica lessingii lessingii* Greene, Eagle Summit (3900 feet elevation), Steese Highway, Alaska, emerged 2.v.69, leg. G. C. D. Griffiths; 1 ♀ from larva 26.vii.68, same plant and locality, emerged 2.v.69, leg. G. C. D. Griffiths. 1 ♂ from larva 30.vii-1.viii.72 on *Arnica cordifolia* Hook., Kathleen Lake (2500 feet elevation), Kluane National Park, Yukon Territory, emerged 15.iii.73, leg. G. C. D. Griffiths. 1 ♀ from larva 3-5.viii.70 on *Arnica cordifolia* Hook., Summit Lake Pass (4300-5000 feet elevation; Alaska Highway mile 392), British Columbia, emerged 5.v.71, leg. G. C. D. Griffiths. 2 ♂♂ 1 ♀ from larvae 15-23.viii.71 on *Arnica cordifolia* Hook., near Mount Cavell Chalet (5800-6700 feet elevation), Jasper National Park, Alberta, emerged 3-7.v.72, leg. G. C. D. Griffiths.

Remarks. — Previously the only known specimen of *tundrensis* was Spencer's holotype, taken by W. R. Mason at Cold Bay (160°W), Alaska, 26.vii.52.

Phytomyza arnicicola Lundqvist 1949

Phytomyza arnicicola Lundqvist. Lundqvist, 1949: 171. Holotype ♂, Torne Lappmark (Sweden), in Zoologiska Institutionen, Lund.

Adult. — As described for *arnicae*, except as follows.

Posterior ors at most 2/3 as long as anterior ors, absent on one side in holotype; normally 3 ori (anteriormost absent only on one side in one specimen), but both anterior pairs much shorter than posterior pair. 3-6 upcurved peristomal setulae. Mesonotal setulae less numerous (acr in 2-4 irregular rows anteriorly; 3-9 postsutural ia). Costal ratio mg_2/mg_4 2.25-2.65. Wing length: ♂, 2.3-2.35 mm; ♀, 2.6 mm (Spencer, in press).

Colour of head varying as in *arnicae* (orbits yellow or somewhat infuscated; antennal pits pale brown in Alaskan specimen, strongly infuscated in type series).

Aedeagus (Fig. 5) with band of spinules on left side shorter, ending well before apex of left basal sclerite; V-shaped sclerotization of medial lobe relatively longer and more strongly upcurved. Ejaculatory apodeme moderately pigmented, shaped as in *arnicae*.

Puparium and third instar larva. — Similar to those of *arnicae*. Anterior spiracles with about 12 bulbs; posterior spiracles with 15-17 bulbs. Puparium of Alaskan specimen dark red-brown, 2.15 mm long (yellowish grey in original material according to Lundqvist).

Mine. — Larvae leaf-miners on *Arnica*. Lundqvist (1949) described the mine as linear, of about 7-10 cm length and 2 mm width, sometimes forming a secondary blotch. This description requires confirmation, as the leaves with the original mines (preserved in Hering's mine herbarium) were small and in poor condition. It is possible that in larger leaves the mines may assume a linear-blotch shape like those of *tundrensis*, which they resemble in containing dark lines of feeding debris. The mine of my Alaskan specimen was not distinguished in the field from mines of *tundrensis* on the same host-plant, and the leaf was unfortunately not fit for preservation by the time the larva had completed feeding. Faeces in original mines deposited as rather large particles, well separated in terminal parts of mine; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

Material examined. — Holotype ♂ from larva 16.vii.47 on *Arnica alpina alpina* (L.), Tuoptertjåkko (950 metres elevation), Torne Lappmark, Sweden, emerged 22.ii.48 (forced), leg. A. Lundqvist.

1 ♂ from larva 26.vii.68 on *Arnica lessingii lessingii* Greene, Eagle Summit (3900 feet

elevation; 65° 29' N, 145° 23' W), Steese Highway, Alaska, emerged 2.v.69, leg. G. C. D. Griffiths.

Remarks. — The only additional specimens of *arnicicola* are two female paratypes from the original series.

The aedeagus of the male holotype has been figured in Spencer's work on Fennoscandian Agromyzidae now in press. That of my Alaskan specimen (Fig. 5) seems virtually identical. Note that in *arnicicola*, as in *arnicae*, there is a patch of spinules on the right side of the aedeagus near the apex of the right basal sclerite (compare Fig. 2); this is absent in *tundrensis*.

Phytomyza saximontana new species

Adult. — Head (Fig. 26) with orbits broadly projecting above eye in lateral view; genae in middle about half eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus 2-2½ times width of eye. Only one ors (posteriorly directed) present (posterior ors absent in all specimens); in most specimens three pairs of inwardly directed ori crowded on anterior part of frons (but four pairs and two pairs in single females); orbital setulae irregularly distributed in 1-2 rows. Peristomal margin with vibrissa and 2-5 upcurved peristomal setulae. Third antennal article rounded distally, with rather short fine pubescence.

3 + 1 dc; acr numerous, in 3-5 rows anteriorly; presutural ia numerous; 3-7 postsutural ia; inner pa about half as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.0-2.4. Wing length: ♂, 2.2-2.6 mm (mean 2.45 mm); ♀, 2.25-2.9 mm (mean 2.6 mm).

Frons largely clear yellow, with ocellar plate contrastingly black; dark colour of vertex variable in extent (either both vt more or less on boundary between dark and pale ground, or vte on dark ground and vti on boundary between dark and pale ground); orbits clear yellow or ochreous, with grey or whitish dusting and spots of infuscation around bases of orbital setae. Face entirely infuscated. Genae yellow. Occiput black. Antennae entirely black, or at most with first article brown. Palpi black; labella yellow or yellowish grey. Thorax colour as in *arnicae*. Legs largely dark, with only tips of front femora distinctly yellow; other femora entirely black, or at most with brownish tips. Abdomen largely dark brown. Basal cone of ovipositor (♀) grey-dusted on basal half to two-thirds.

Male postabdomen and genitalia similar to those of *arnicae*, but with clear differences in form of aedeagus (Fig. 6-7). Spinules finer, densely arranged in more or less semicircular band at apex of basal section below distal section (this band about equally developed on both sides or slightly shorter on right side); distal section with pigmented distiphallus. Ejaculatory apodeme moderately pigmented, shaped as in *arnicae*.

Puparium and third instar larva. — Similar to those of *arnicae*. Anterior spiracles with 12-15 bulbs; posterior spiracles with 17-23 bulbs. Puparia brown to dark red-brown, 1.9-2.2 mm long, with prominent anal lobes.

Mine. — Larvae leaf-miners on *Arnica*. Mine (Fig. 29) basically linear (about 2 mm wide terminally), but in most cases convolute with secondarily blotchy areas, appearing white or greenish white in reflected light when fresh; faeces deposited mostly as particles, but in some cases partly forming short beaded strips; mines formed entirely on upper surface of leaf, or largely so but with terminal channel on lower surface; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

Types. — Holotype ♂, 3 ♂♂ 1 ♀ paratypes from larvae 23.viii.71 on *Arnica mollis* Hook., near Mount Cavell Chalet (7300 feet elevation; 52° 41' N, 118° 2' W), Jasper National Park, Alberta, emerged 8.v.72, leg. G. C. D. Griffiths. 6 ♂♂ 7 ♀♀ paratypes from larvae 15-23.viii.71

on *Arnica cordifolia* Hook., same locality (5800-6700 feet elevation), emerged 8-9.v.72, leg. G. C. D. Griffiths.

Remarks. — The name *saximontana* is here used to mean “of the Rocky Mountains”, a sense well established in botanical nomenclature. In addition to the host-plants stated above, I also pressed a sample of mines of this species on *Arnica latifolia* Bong. at the type locality.

This species can be reliably separated from the other *Arnica*-feeders on external characters (small eyes; posterior ors absent), as well as by the distinctive aedeagus.

Phytomyza californica new species (♂)

Adult. — Head with orbits scarcely projecting above eye in lateral view; genae in middle about 1/4 of eye height; eyes apparently bare. Frons at level of front ocellus about twice width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors 2/3 as long as anterior ors; anterior ori 2/3 as long as posterior ori; orbital setulae irregularly distributed in 1-2 rows. Peristomal margin with vibrissa and 4-5 upcurved peristomal setulae. Third antennal article rounded distally, with short pubescence.

3 + 1 dc; acr in 4 rows; 6-8 presutural ia; 8-9 postsutural ia; inner pa about 1/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 3.1. Wing length 2.4 mm.

Frons clear yellow except dark ocellar plate (both vt on yellow ground). Face completely yellow, scarcely infuscated in antennal pits. Genae yellow. Occiput largely dark, but yellow at sides ventrally. Antennae with first article yellowish, second article yellow-brown, third article brown. Palpi yellow-brown; labella yellow. Mesonotum dark centrally (weakly shining, finely grey-dusted), but with strongly contrasting broad whitish-yellow side bands which anteriorly extend inwards along its anterior margin to level of either row of dc and posteriorly extend inwards and narrowly fuse in front of scutellum (both pa on boundary between dark and pale ground); humeral calli largely whitish yellow, with small brownish patch in centre; scutellum entirely whitish yellow on dorsal surface, infuscated only along sides; upper pleura extensively whitish yellow, but with dark anteroventral area on mesopleuron (ptero-pleuron with only small brownish patches); propleuron dark; sternopleuron and hypopleuron largely dark, but pale dorsally along sutures. Wing base and squamae whitish, latter with dark fringe. Legs largely dark, with tips of femora and bases of tibiae contrastingly whitish yellow; tibiae and tarsi largely brown. Abdomen largely brown.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres delimited from periandrium by distinct suture on outer side, bearing numerous fine setulae. Ventral extensions of pregonites inconspicuous, more or less membranous. Aedeagus as Fig. 8-9; basal sclerites narrow; spinules on dorsal surface of basal section in three discrete groups, (i) band of 9 spinules near dorsal margin of left basal sclerite (shown on Fig. 8), (ii) patch of 6 spinules on opposite side near dorsal margin of right basal sclerite (not shown on Fig. 8), and (iii) broad band on centre-line situated more basally than both preceding (shown on Fig. 8); sclerites of medial lobe fused distally, forming V; distal section with pair of large spines at base, with pair of slender weakly pigmented tubules (distiphallus) arising from cylindrical area of sclerotization about ejaculatory duct. Ejaculatory apodeme as Fig. 10.

Puparium and third instar larva. — The single preserved puparium is dark brown, about 2 mm long, similar to that of *Phytomyza tussilaginis* Hendel (see Part II, Fig. 26), but with about 40 bulbs on the posterior spiracles; the anterior spiracles have been lost.

Mine. — Larvae leaf-miners on *Senecio triangularis* Hook. The single complete mine (Fig. 32) is entirely linear, but somewhat convolute, about 2 mm wide terminally, formed largely on lower surface of leaf, but with short full-depth stretch visible also on upper surface; faeces

deposited as rather large particles, widely separated (by several mm) in terminal part of mine; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

Type. — Holotype ♂ from larva on *Senecio triangularis* Hook., Summit of Luther Pass (7740 feet elevation), El Dorado County, California, emerged 28.viii.48, leg. K. E. Frick (puparium preserved separately in alcohol).

Remarks. — The host-plant was given as *Senecio lugens* Richards. var. *exaltatus* Gray in Frick's records, and the specimen so labelled. This was a misidentification, since the pressed leaves (Frick's Lot 94-2) clearly belong to *S. triangularis* Hook. Additional samples of the mines are needed to determine whether they can be reliably separated from mines of *Phytomyza alpina* Groschke (treated in Part II).

Phytomyza homogyneae Hendel 1927

Phytomyza homogyneae Hendel. Hendel, 1927: 261. —1935: 415. Hering, 1927: 113. —1936: 273. —1957: 543. Beiger, 1973: 675. Holotype ♂, Walchsee (Austria), in Naturhistorisches Museum, Vienna.

Adult. — Head with orbits not projecting above eye in lateral view; genae in middle about 1/5 of eye height; eyes with only sparse fine pubescence. Frons at level of front ocellus less than twice width of eye. Ors directed posteriorly, ori directed inwardly; posterior ors 2/3 to 3/4 as long as anterior ors; anterior ori weak, about 1/3 as long as posterior ori; orbital setulae few, one-rowed. Peristomal margin with vibrissa and 4-7 upcurved peristomal setulae. Third antennal article rounded distally, with rather short pubescence.

3 + 1 dc; acr numerous, in 5-6 rows anteriorly; presutural and postsutural ia numerous; inner pa about 2/3 as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.7-2.9. Wing length 2.5-2.55 mm (not 2.0 mm as stated by Hendel).

Frons clear yellow centrally, with ocellar plate and vertex contrastingly black (vte on dark ground; vti on boundary between dark and pale ground); orbits partly yellow, somewhat infuscated along eye margins and around bases of orbital setulae. Face yellow towards sides and centrally above prelabrum, extensively infuscated in antennal pits. Genae yellow. Occiput black. Antennae with first article yellow-brown, second and third articles black. Palpi black; labella yellow. Mesonotum weakly shining, finely grey-dusted, black centrally, brown on sides with traces of yellowish white at corners of humeral calli. Scutellum black. Pleura black except narrow whitish band along dorsal margin of mesopleuron and white seam of mesopleural suture. Wing base and squamae contrastingly whitish yellow, latter with dark fringe. Legs largely dark, with tips of femora contrastingly yellow; tibiae and tarsi brown. Abdomen largely dark brown, becoming yellow-brown on sides at base. Basal cone of ovipositor (♀) grey-dusted on about basal half.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres partly delimited from periandrium by suture on outer side, bearing numerous fine setulae. Pregonites extending ventrally, shielding base of aedeagus at rest. Aedeagus as Fig. 11-12; basal sclerites long, narrow at base but each with expanded distal area immediately anterior to conspicuous patch of spinules (these patches about equally developed on both sides and joined by few large spinules across dorsal surface of aedeagus); sclerotization of medial lobe V-shaped, fused at base with basal sclerites; distal section with pair of large projecting spinules at base and characteristically shaped distiphallus. Ejaculatory apodeme rather small (Fig. 13).

Puparium and third instar larva. — Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles knob-shaped, with 11-12 bulbs in widely open ellipse. Posterior spiracles close together, on short broad processes (not much raised above level of

last segment), with 21 bulbs in narrow irregular ellipse. Puparium brown, 2.0 mm long; anal lobes not prominent.*

Mine. — Larvae leaf-miners on *Homogyne*. Mine (Hendel, 1927; Hering, 1936) entirely linear, up to 3 mm wide terminally, appearing whitish or greenish in reflected light, largely on upper surface of leaf but with terminal channel on lower surface; faeces deposited in short beaded strips initially, then as large particles; larvae leaving leaf through semicircular slit on lower surface before puparium formation.

A figure of the mine has been given by Hering (1936, 1957).

Material examined. — Holotype ♂ from larva 13.vii.23 on *Homogyne alpina* (L.), Walchsee, Tirol, Austria, emerged 19.iv.24, leg. F. Hendel. 1 ♀ from larva 14.vii.62 on *Homogyne alpina* (L.), Schöneben (Mühlviertel), Böhmerwald, Austria, emerged 30.vii.62, leg. E. M. Hering (no. 6968).

Other records. — This species is known only from Central Europe. The species from Japan reported as *homogyneae* is in my opinion distinct (see below). Additional European records are as follows.

- Italy — Pragser Wildsee (1500 metres elevation), Alto Adige, 30.vii.60, on *Homogyne discolor* (Jacq.) (sheet in Hering's mine herbarium).
- Germany — Oberwiesenthal, Erzgebirge, on *Homogyne alpina* (L.) (Buhr, 1964); Aggenstein, Pfronten/Bayern, on *Homogyne alpina* (L.) (sheet in Hering's mine herbarium).
- Czechoslovakia — Jeseník (Starý, 1930), on *Homogyne alpina* (L.).
- Poland — Reported by Beiger (1958, 1973) and Nowakowski (1962) on *Homogyne alpina* (L.) from various localities in the Tatry Mountains (1100-1700 metres elevation); also in the Silesian Mountains (Hering, 1927).

Phytomyza sp. (Japan)

"*Phytomyza homogyneae* Hendel". Sasakawa, 1961: 453.

Sasakawa's figure of the aedeagus of his *homogyneae* (Fig. 127d) does not agree with that of the holotype. According to this figure, there are no patches of spinules on the basal section and the distiphallus is longer than in the holotype. Clearly Sasakawa had before him a distinct, though closely related, species. Subsequently he has recorded this species also from Formosa (Sasakawa, 1972).

Sasakawa gives *Aster trinervius* Roxb., as well as *Homogyne* sp., as hosts of his species. This seems an unlikely host combination, which I cannot accept unless substantiated by dissection of males bred from both hosts.

Phytomyza aronici Nowakowski 1962

Phytomyza aronici Nowakowski. Nowakowski, 1962: 225. Holotype ♂, Tatry Mountains (Poland), in Instytut Zoologiczny, Polska Akademia Nauk, Warsaw.

This species was described by Nowakowski on the basis of material bred from linear mines on *Doronicum clusii* (All.) at 1600-2400 metres elevation in the Tatry Mountains.

I have nothing to add to the very detailed original description. This species is very close to

* The above description is based on a puparium mounted with Hering's Schöneben specimen. Beiger (1973) has just published a description and figures of two larvae from the Tatry Mountains (Poland). She states that the anterior spiracles have about 15 bulbs and the posterior spiracles about 26 bulbs.

alpina (see my description in Part II), from which I can distinguish it only by the following details of the male aedeagus: the paramesophalli converge towards the base of the distiphallus (in *alpina* parallel) and the left group of spinules on the basal section lies closer to the apex of the left basal sclerite.

Hering has subsequently attributed to *aronici* herbarium sheets of mines from Austria and Bavaria on *Doronicum austriacum* Jacq. and from Roumania on *Doronicum pardalianches* L.; and even a collection on *Doronicum* from Eastern Asia (Hering & Spencer, 1968: 98). These records should be regarded as doubtful, until they can be checked by dissection of bred flies from these areas.

Phytomyza daronici Hering 1924 (♀)

Phytomyza daronici Hering. Hendel, 1923: 392. — 1935: 393. Hering, 1924: 39. — 1927: 121.

Starý, 1930: 231. Beiger, 1973: 678. Holotype ♀, Moldova noua (Roumania), in Zoologisches Museum, Humboldt Universität, Berlin.

The available information on this Central European species remains that presented by Hendel (1935), with the addition of subsequent records for Bulgaria (Buhr, 1941) and Slovenia (Spencer in Coe, 1962) and a larval description based on material from the Polish Tatry by Beiger (1973). The male genitalia are undescribed and no males have been traced in collections. The type was bred from *Doronicum columnae* Tenore (= *cordatum*). Mines on *Doronicum austriacum* Jacq. and *D. pardalianches* L. have also been attributed to this species (the latter on a sheet in Hering's mine herbarium from Hofgeismar, Hessen, the most northerly reported locality).

Phytomyza adenostylis Hering 1926 (♀)

Phytomyza adenostylis Hering. Hering, 1926: 464. — 1927: 119. De Meijere, 1928: 164.

Hendel, 1934: 331. Holotype ♀, Bad Pfäfers (Switzerland), in Zoologisches Museum, Humboldt Universität, Berlin.

Again a Central European species of which no males have been traced in collections. Since Hendel's (1934) treatment it has been reported by Hartig (1939) from various localities in Alto Adige (Italy). Hartig gives *Adenostyles alliariae* (Gouan) as a host, in addition to *A. glabra* (Mill.) from which the species was originally bred.

Phytomyza conyzae Hendel 1920

Phytomyza arnicophila Hering. Hering, 1931: 544. Syntypes ♂♀, Holstein (Germany), in Zoologisches Museum, Humboldt Universität, Berlin. Synonymy after Hendel, 1935: 384.

I have compared the genitalia of the male syntype of *arnicophila* with those of a specimen bred from *Inula conyza* DC. in England. I can see no difference between them and therefore accept Hendel's synonymy, as also have de Meijere (1937: 217) and Spencer (in press).

Since this species is primarily a miner of Inuleae, I do not treat it here. The extensive further synonymy proposed by Hendel (1935) needs to be checked by dissection of all relevant types. Attacks on *Arnica* have been reported only in Denmark (Sønderup, 1949) and neighbouring Holstein, where the original series of *arnicophila* was bred from *Arnica montana* L. In most parts of Europe it seems that only Inuleae are selected as hosts.

Additional notes on species treated in Part II

Phytomyza tussilaginis Hendel subsp. *kevani* Griffiths

I described this subspecies on the basis of specimens from arctic tundra near the Mackenzie Delta. Additional material has now been obtained from alpine tundra in the St. Elias range, as follows.

1 ♂ from larvae 18-26.vii.72 on *Petasites frigidus* (L.), near S end Kluane Lake (3500-4000 feet elevation), Yukon Territory, emerged 1.v.73, leg. G. C. D. Griffiths. 1 ♂ 1 ♀ from larvae 1.viii.72 on *Petasites frigidus* (L.), above Kathleen Lake (4500 feet elevation), Kluane National Park, Yukon Territory, emerged 1-4.v.72, leg. G. C. D. Griffiths.

This additional material confirms that the mean costal ratio (mg_2/mg_4) in *kevani* is lower than in the two other subspecies of *tussilaginis*; the mean of the five available specimens is 2.6 (range 2.5-2.7). Revised wing length data is: ♂, 2.2-2.7 mm (mean of four specimens, 2.4 mm); 1 ♀, 2.9 mm. A revised distribution map for the two North American subspecies is given at Fig. 33.

Phytomyza alpina Groschke

The following additional series have been obtained: 5 ♂♂ 4 ♀♀ from larvae 15-24.vii.72 on *Senecio lugens* Richards., near S end Kluane Lake (4500-5000 feet elevation), Yukon Territory, emerged 10-12.v.73, leg. G. C. D. Griffiths; 4 ♂♂ 3 ♀♀ from larvae 22-26.vii.72 on *Senecio ogorukensis* Packer, same locality (3000-4500 feet elevation), emerged 4-14.v.73, leg. G. C. D. Griffiths.

Besides adding a new host record, these collections are also of interest because some of the mines on *Senecio lugens* Richards. become distinctly blotchy terminally, as in mines from Europe. So it appears that variation in the form of the mine occurs within populations and is not geographically correlated, contrary to the implication of my previous comments.

In summarizing the European distribution of this species, I omitted one published record: Hering (1962) reported that the mines occurred commonly on *Senecio subalpinus* Koch at 1600 metres near Brunnstein-See, Warscheneck-Gebirge, Austria.

Just before publication of Part II, Beiger (1972) published a figure of the genitalia of this species, which she misidentified as *tussilaginis*. She has subsequently corrected this (Beiger, 1973), and given a detailed larval description based on material from *Senecio nemorensis* L. and *S. subalpinus* Koch in the Polish Tatry. The previously misidentified specimen was bred from *Petasites kablikianus* Tausch., constituting the first record of *alpina* on *Petasites* in Europe.

Phytomyza senecionis Kaltenbach

When writing my description in Part II, I had before me only a single male whose genitalia had been previously removed and glued to the mount. Subsequently K. A. Spencer has drawn to my attention that the distal section of the aedeagus of this specimen had been damaged. I am therefore publishing a replacement figure (Fig. 14), based on a specimen from Alter Stolberg, Südhaz (Germany), lent me by Spencer. Contrary to my previous description, the bifid distiphallus is well developed in this species.

(b) the *Phytomyza robustella* group

In addition to the species of this group reported from Senecioneae in Part II, I have bred three further species from leaf mines on *Arnica* in North America. Externally the adults of these species closely resemble *Phytomyza farfarae* Hendel, *P. hypophylla* Griffiths and *P. lugentis* Griffiths (the last three described in Part II). Therefore I am giving only brief descriptions, to be compared for further details with the long description of *farfarae* given in Part II (Griffiths, 1972: 391). The three *Arnica*-feeding species all have white puparia with small spiracles, again as in *farfarae*, *lugentis* and *hypophylla* (see Part II, Fig. 27). Morphological differences between the puparia of these six species have not been noted, but there are differences in the form of the mines between most, if not all, of them (subject to confirmation only in the case of *oreas* and *arnicivora*). I have also included here the description of a new *Senecio*-feeding species from the Frick collection. This too belongs to the complex of species close to *farfarae*.

The known distribution of the three *Arnica*-feeders is shown on Fig. 34. One species (*oreas* n. sp.) is found at higher elevations (near or above timberline), while another (*campestris* n. sp.) has been collected only at lowland sites. The previously described species (*arnicivora*) is known only from the original collection, in montane forest at middle elevation in Jasper National Park. Diagnostic criteria for distinguishing these three species from one another are as follows.

	<i>oreas</i>	<i>campestris</i>	<i>arnicivora</i>
frons colour	largely brown or red-brown	largely yellow or yellow-brown	largely whitish yellow
face colour	dark brown or black	brown	yellow-brown
distiphallus (♂)	anterior margin bent downwards (Fig. 15)	anterior margin almost straight (Fig. 18)	anterior margin bent downwards (Fig. 21)
medial lobe of aedeagus (♂)	with pigmented sclerotized central spur (Fig. 15-16)	with membranous central spur (Fig. 18-19)	with membranous central spur (Fig. 21)
ejaculatory apodeme (♂)	small (Fig. 17)	large (Fig. 20)	rather small
faecal pattern in mine	narrowly separated particles or beaded strips (Fig. 30)	particles mostly separated by over 1 mm (Fig. 31)	mostly beaded strips

Phytomyza oreas new species

Adult. — As described for *farfarae* (Part II: 391), except as follows.

Third antennal article with somewhat longer upcurved pubescence distally.

Costal ratio mg_2/mg_4 1.6-2.0. Wing length: ♂, 2.4-2.6 mm (mean 2.5 mm); ♀, 2.5-3.0 mm (mean 2.8 mm).

Head darker coloured (compare also *hypophylla* and *lugentis*); centre of frons brown or red-brown, with orbits infuscated and grey-dusted to variable degree (entirely so in some specimens); face largely dark brown or black. Basal cone of ovipositor (♀) grey-dusted on basal half to two-thirds.

Male postabdomen and genitalia similar to those of *farfarae* in most respects, but with clear differences in form of aedeagus (Fig. 15-16). Distiphallus with its anterior margin bent downwards (contrast *campestris* and *hypophylla*); medial lobe with loop of unpigmented sclerotization around margin and conspicuous central spur (sclerotized and pigmented). Ejaculatory apodeme smaller (Fig. 17).

Puparium and third instar larva. — As in *farfarae*. Spiracles knob-shaped, anterior with 8-10 bulbs, posterior with 5-10 bulbs. Puparia white, 2.1-2.6 mm long.

Mine. — Larvae leaf-miners on *Arnica*. Mine (Fig. 30) entirely linear, 13-16 cm long, about 1 mm wide terminally; faeces deposited as fine particles, in some cases forming beaded strips; mines confined to upper surface of leaf, or at most with short terminal channel on lower surface leading to pupation site (the latter in all cases on lower surface). Puparium with its ventral surface adjacent to lower surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. — Holotype ♂, 5 ♂♂ 4 ♀♀ paratypes from puparia 15-17.viii.71 on *Arnica cordifolia* Hook., near Mount Cavell Chalet (6200-7200 feet elevation; 52° 41' N, 118° 3' W), Jasper National Park, Alberta, emerged 20-31.viii.71, leg. G. C. D. Griffiths. 1 ♂ 1 ♀ paratypes from puparia 5.viii.70 on *Arnica cordifolia* Hook., Summit Lake Pass (5000 feet elevation; Alaska Highway mile 392), British Columbia, emerged 11-17.viii.70, leg. G. C. D. Griffiths; 2 ♂♂ 1 ♀ paratypes from puparia 5.viii.70 on *Arnica lessingii lessingii* Greene, same locality and elevation, emerged 13-19.viii.70, leg. G. C. D. Griffiths. 1 ♂ 2 ♀♀ paratypes from puparia 15 and 26.vii.72 on *Arnica alpina* (L.) subsp. *angustifolia* (M. Vahl), near South end Kluane Lake (4500 & 3000 feet), Yukon Territory, emerged 2-7.viii.72, leg. G. C. D. Griffiths.

Remarks. — Mines at the type locality were also common on *Arnica latifolia* Bong. I also collected larvae probably of this species on *Arnica lessingii lessingii* Greene at Eagle Summit (3900 feet elevation, Steese Highway, Alaska) on 17 & 19.vii.68, but obtained only parasites from this sample.

The name *oreas* is a transliteration of the Greek *ὄρειάς*, meaning a mountain-nymph. Mines of this species are often abundant in alpine meadows and in forest clearings near timberline. The collections at relatively low elevations near Kluane Lake were from canyon walls.

Phytomyza campestris new species

Adult. — As described for *farfarae* (Part II: 391), except as follows.

3-6 upcurved peristomal setulae. Third antennal article with somewhat longer upcurved pubescence distally (as in *oreas*).

Costal ratio mg_2/mg_4 1.7-2.0. Wing length: ♂, 2.1-2.5 mm (mean 2.3 mm); ♀, 2.3-2.5 mm (mean 2.4 mm).

Male postabdomen and genitalia similar to those of *farfarae* in most respects, but with clear differences in form of aedeagus (Fig. 18-19). Distiphallus with its anterior margin almost straight (contrast *oreas* and *arnicivora*); medial lobe with loop of marginal sclerotization (either completely unpigmented or with short lateral stretches of pigmentation), with membranous central spur (contrast *oreas*). Ejaculatory apodeme rather large (Fig. 20).

Puparium and third instar larva. — As in *farfarae*. Spiracles knob-shaped, anterior with 8-11 bulbs, posterior with 6-8 bulbs. Puparia white, 1.9-2.25 mm long.

Mine. — Larvae leaf-miners on *Arnica*. Mine (Fig. 31) similar to that of *oreas*, but longer

(20-22 cm), with larger, more widely spaced faecal particles (mostly separated by over 1 mm); mines on upper or lower surface of leaf, with pupation following on lower surface at end of mine channel. Puparium with its ventral surface adjacent to lower surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. — Holotype ♂, 4 ♂♂ 9 ♀♀ paratypes from puparia 22.vii.70 on *Arnica chamissonis* Less. subsp. *foliosa* (Nutt.), Elk Island National Park (1 mile W Soapholes; 53° 37' N, 112° 50' W), Alberta, emerged 26.vii-3.viii.70, leg. G. C. D. Griffiths. 3 ♂♂ paratypes from puparia 20-21.vii.68 on *Arnica alpina* (L.) subsp. *attenuata* (Greene), Ketchem Creek (65° 31' N, 144° 41' W), Alaska, emerged 24.vii-1.viii.68, leg. G. C. D. Griffiths.

Remarks. — Both collections of this species were from lowland sites (hence the name *campestris*, meaning "of the plains").

Phytomyza arnicivora Sehgal 1971 (♂)

Phytomyza arnicivora Sehgal. Sehgal, 1971: 357. Holotype ♂, Jasper National Park (Alberta), in Canadian National Collection, Ottawa.

Adult. — As described for *farfarae* (Part II: 391), except as follows.

Third antennal article with somewhat longer upcurved pubescence distally (as in *oreas*).

Costal ratio mg_2/mg_4 1.9. Wing length 2.4 mm.

Frons largely whitish yellow, without infuscation on orbits but becoming somewhat ochreous in centre; face largely yellow-brown, scarcely infuscated; genae yellow.

Male postabdomen and genitalia similar to those of *farfarae* in most respects, but with clear differences in form of aedeagus (Fig. 21). Distiphallus with its anterior margin bent downwards (contrast *campestris*); medial lobe with loop of unpigmented sclerotization around margin, with only membranous central spur (contrast *oreas*). Ejaculatory bulb rather small (Sehgal, 1971, Fig. 85).

Puparium and third instar larva. — As in *farfarae*. Spiracles knob-shaped, anterior with 8-9 bulbs, posterior with 6-7 bulbs. Puparium white, 2.2 mm long.

Mine. — Larvae leaf-miners on *Arnica*, forming narrow linear mines (about 1 mm wide terminally), similar to those of *oreas* but in most cases partly or largely on lower surface of leaf; faeces mostly deposited in beaded strips. Puparium with its ventral surface adjacent to lower surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Material examined. — Holotype ♂ from puparium 16.vii.69 on *Arnica cordifolia* Hook., near S end Medicine Lake (4900 feet elevation; 52° 51' N, 117° 44' W), Jasper National Park, Alberta, emerged 24.vii.69, leg. G. C. D. Griffiths.

Remarks. — In the original description Sehgal stated that the third antennal article was "with normal pubescence". It seems to me that this pubescence is similar to that in *oreas* and *campestris*, somewhat longer than in most *Phytomyza* species. In all other respects I can confirm the original description. The holotype is still the only available specimen.

Additional samples of the mines are needed to determine how reliably they can be separated from mines of *oreas*.

Phytomyza integerrimi new species (♂)

Adult. — As described for *farfarae* (Part II: 391), except as follows.

Two equal pairs of ors in two specimens (as normally in *robustella* group), but only one pair in one specimen. 4-5 upcurved peristomal setulae.

Costal ratio mg_2/mg_4 1.5-1.6. Wing length 2.5-2.8 mm.

Head slightly darker coloured; centre of frons brown; face dark brown; genae brown.

Male postabdomen and genitalia similar to those of *farfarae* in most respects, but with clear differences in form of aedeagus (Fig. 22-23). Distiphallus relatively longer, flanked basally by large sclerotized (but unpigmented) lateral lobes; medial lobe with loop of marginal sclerotization, largely unpigmented (with only short distal strips of pigmentation), with membranous central spur. Ejaculatory apodeme rather large (Fig. 24).

Types. — Holotype ♂, 2 ♂♂ paratypes from mines 10.vi.48 on *Senecio integerrimus* Nutt., Ochoco National Forest (between Mitchell and Prineville), Oregon, leg. K. R. Hobbs (in Frick collection).

Remarks. — The mines and immature stages of this species were unfortunately not preserved.

Additional records of species treated in Part II

Phytomyza hypophylla Griffiths

The following additional series has been obtained: 1 ♂ 2 ♀♀ from puparia 18.vii.72 on *Petasites frigidus* (L.), near S end Kluane Lake (4500-5000 feet elevation on Slims Tundra), Yukon Territory, emerged 5-7.viii.72, leg. G. C. D. Griffiths.

Phytomyza lugentis Griffiths

The following additional series has been obtained: 2 ♀♀ from puparia 15-24.vii.72 on *Senecio lugens* Richards., near S end Kluane Lake (4000-5000 feet elevation), Yukon Territory, emerged 27.vii & 17.viii.72, leg. G. C. D. Griffiths.

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Fig. 1-3. *Phytomyza arnicae* Hering, syntype ♂: 1, aedeagus in left lateral view (BS basal section of aedeagus, DS distal section of aedeagus, ML medial lobe, PHPH phallosphere); 2, distal parts of aedeagus in right lateral view; 3, ejaculatory apodeme. Fig. 4. *Phytomyza tundrensis* Spencer (♂) (Alberta), aedeagus in left lateral view. Fig. 5. *Phytomyza arnicicola* Lundqvist (♂) (Alaska), aedeagus in left lateral view. Fig. 6-7. *Phytomyza saximontana* n. sp., holotype ♂: 6, aedeagus in left lateral view; 7, distal section of aedeagus in dorsal view.

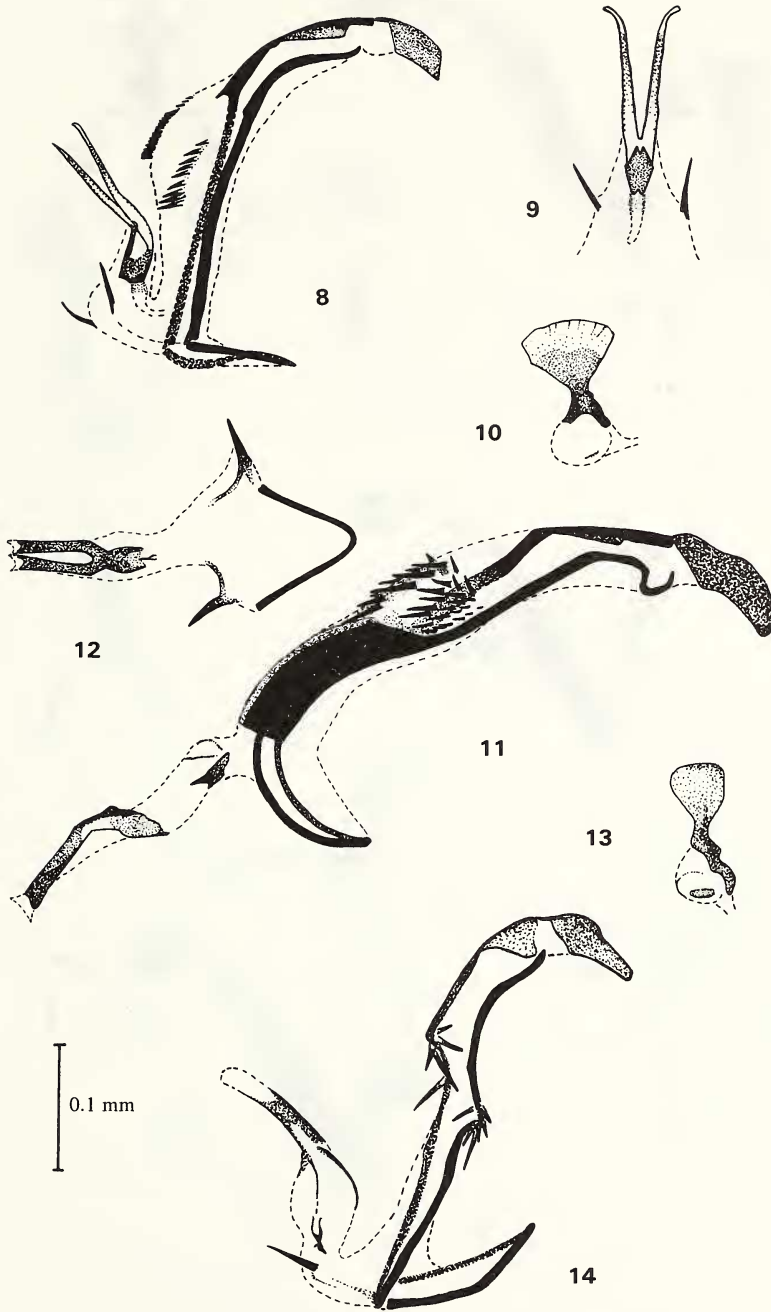


Fig. 8-10. *Phytomyza californica* n. sp., holotype ♂: 8, aedeagus in left lateral view; 9, distal section of aedeagus in \pm antero-ventral view; 10, ejaculatory apodeme. Fig. 11-13. *Phytomyza homogynae* Hendel, holotype ♂: 11, aedeagus in left lateral view; 12, distal section and medial lobe of aedeagus in ventral view; 13, ejaculatory apodeme. Fig. 14. *Phytomyza senecionis* Kaltenbach (♂) (Germany), aedeagus in left lateral view.

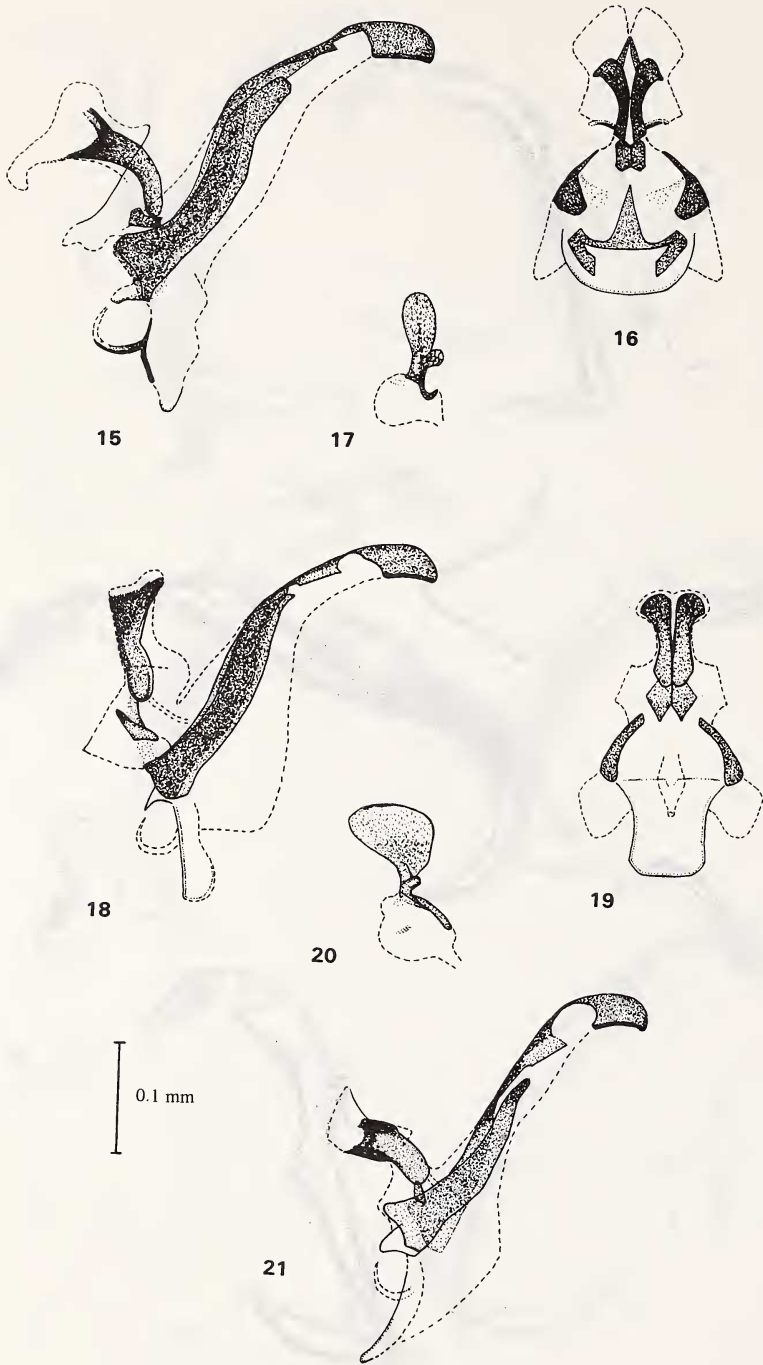


Fig. 15-17. *Phytomyza oreas* n. sp., holotype ♂: 15, aedeagus in left lateral view; 16, distal section and medial lobe of aedeagus in anteroventral view; 17, ejaculatory apodeme. Fig. 18-20. *Phytomyza campestris* n. sp., holotype ♂: 18, aedeagus in left lateral view; 19, distal section and medial lobe of aedeagus in \pm anteroventral view; 20, ejaculatory apodeme. Fig. 21. *Phytomyza arnicivora* Sehgal (holotype ♂), aedeagus in left lateral view.

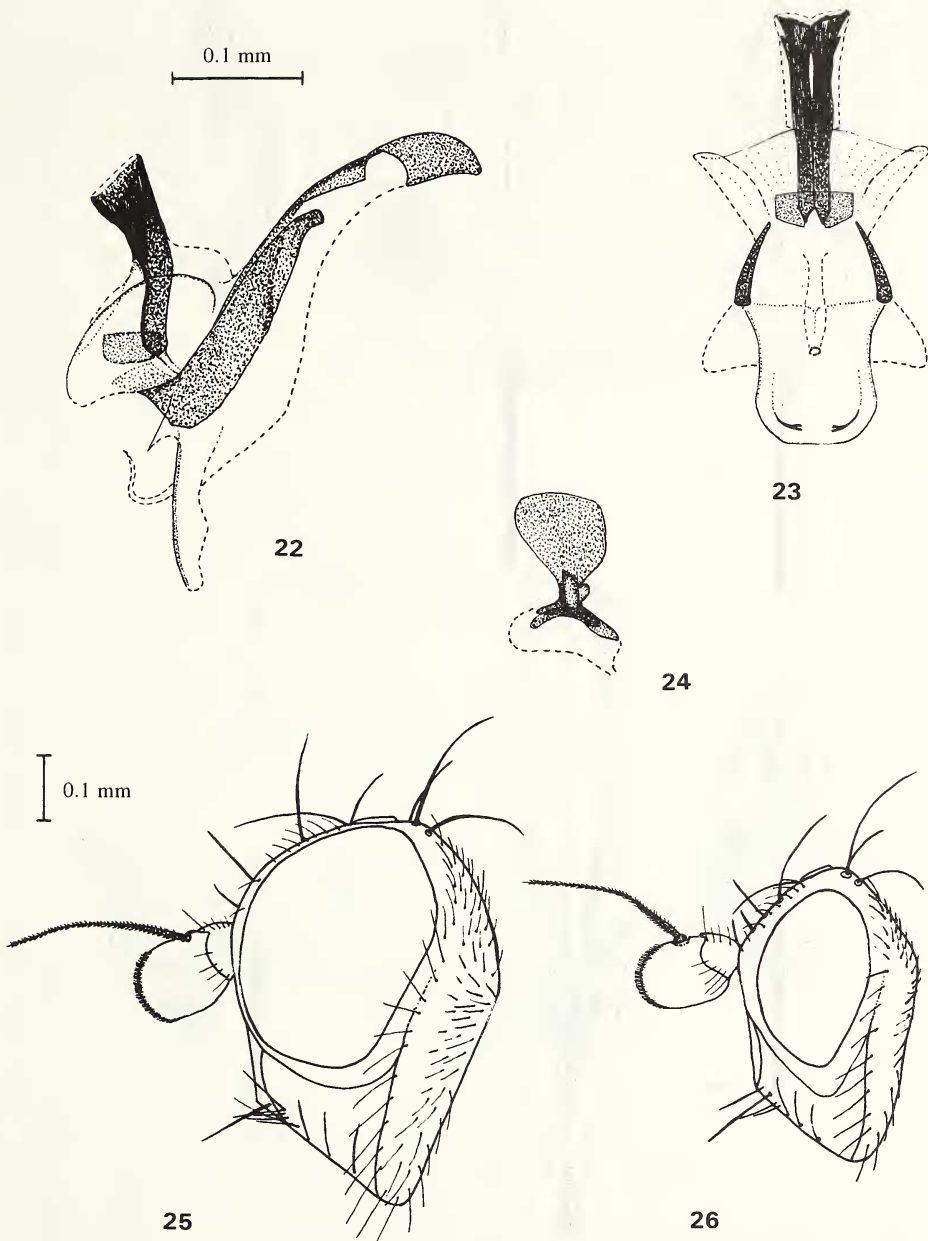


Fig. 22-24. *Phytomyza integerrimi* n. sp., holotype ♂: 22, aedeagus in left lateral view; 23, distal section and medial lobe of aedeagus in \pm anteroventral view; 24, ejaculatory apodeme. Fig. 25. *Phytomyza arnicae* Hering (Alberta), head in left lateral view. Fig. 26. *Phytomyza saximontana* n. sp., head in left lateral view.

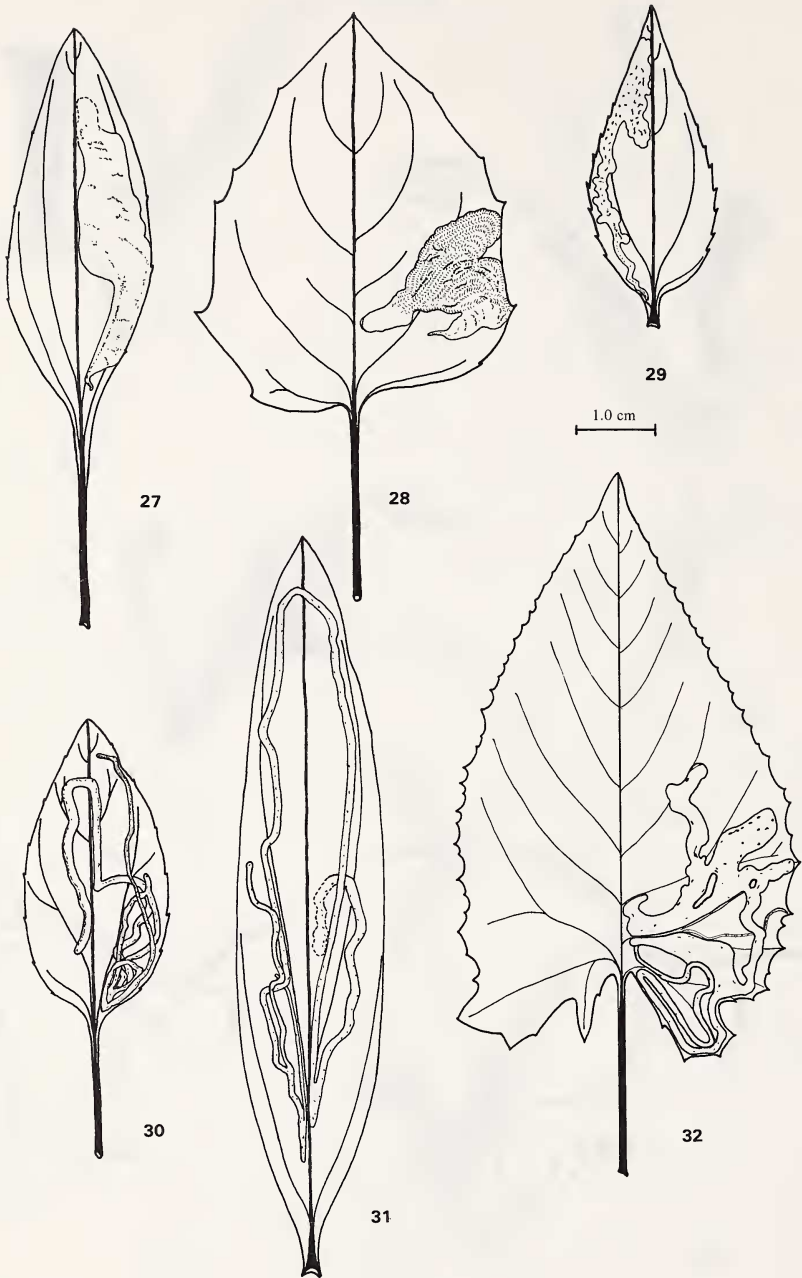


Fig. 27. Leaf of *Arnica alpina* (L.) subsp. *tomentosa* (Macoun) with mine of *Phytomyza arnicae* Hering. Fig. 28-30. Leaves of *Arnica cordifolia* Hook. with mines of: 28, *Phytomyza tundrensis* Spencer; 29, *Phytomyza saximontana* n. sp.; 30, *Phytomyza oreas* n. sp. Fig. 31. Leaf of *Arnica chamissonis* Less. subsp. *foliosa* (Nutt.) with mine of *Phytomyza campestris* n. sp. Fig. 32. Leaf of *Senecio triangularis* Hook. (lower surface) with mine of *Phytomyza californica* n. sp.

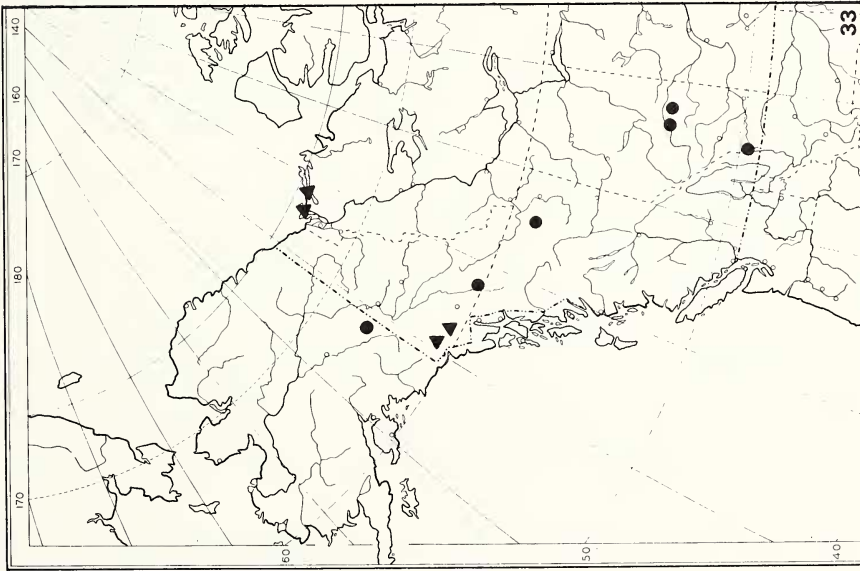
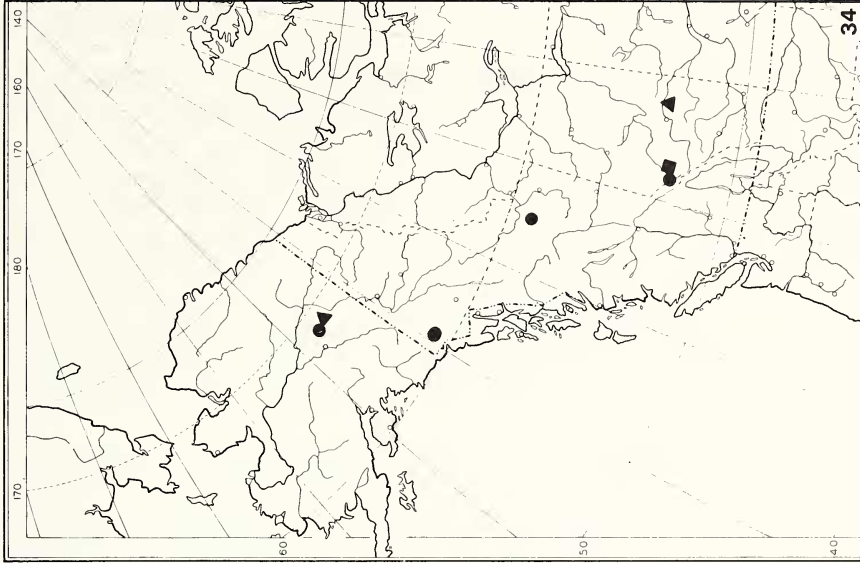


Fig. 33. Collection sites for *Phytomyza tussilaginis* Hendel in North America (● subsp. *petasiti*; ▲ subsp. *oreas* n. sp.; ▲ *P. campestris* n. sp.; ■ *P. arnichora* Sehgal).
Fig. 34. Collection sites for *Arnica*-feeding species of the *Phytomyza robustella* group (● subsp. *kevanii*).

